

REGION SEGMENTATION OF COLOR IMAGE

DETAILED DESCRIPTION OF THE
INVENTION

[0001] 1. Field of the Invention

[0002] The present invention relates to a technique for dividing an image region of a color image according to colors.

[0003] 2. Description of the Related Art

[0004] It is sometimes desired to divide an image region of a color image in order to selectively process a desired region of a specific color. **FIGS. 10A and 10B** illustrate conventional region dividing (also referred to as "region segmentation"). Initially in this method, colors of respective objects in a color picture are specified as a plurality of representative colors. Distances between each pixel color in the color image and the plural representative colors are then calculated in the RGB color space. Each pixel is then categorized into a cluster around a representative color that provides the smallest distance. The term "cluster" refers to a group of plural colors associated with one representative color. In this specification, process for categorizing an arbitrary color into one of the plural representative colors is also referred to as "clustering".

[0005] **FIG. 10A** illustrates the result of an appropriate clustering process. In this figure, a horizontal axis indicates R (red) component and a vertical axis indicates B (blue) component. Color of each pixel is represented in the three-dimensional RGB space in actual cases, but a two-dimensional space is used herein for convenience of illustration. Black dots represent colors of pixels (also referred to as "individual colors") in the color image, and larger open circles represent representative colors of respective objects. It is appreciated from the example of **FIG. 10A** that all pixel colors are appropriately grouped into objects 1-4.

[0006] Even if an object in a color image has uniform original color, the brightness values of pixel colors of the object may show a considerable dispersion depending on the illumination on the object. Specifically, colors with higher brightness are plotted distant from the origin of the RGB color space, and colors with lower brightness are plotted close to the origin. In such cases, dots representing pixel colors of the object will disperse in a wide range around a direction of the color vector that represents the original color of the object.

[0007] **FIG. 10B** illustrates the clustering result where pixel colors of object 1 and object 2 are dispersed in a wide range around the directions that connect their representative colors with the origin O, respectively. In this figure, dashed lines represent appropriate grouping of pixel dots, and solid lines represent inappropriate grouping actually performed.

[0008] Conventional techniques for region segmentation sometimes mistakenly recognize pixel colors that originally belong to a same object of a same color as colors of different objects because of their brightness dispersion. Such problem is particularly significant in region segmentation of a color picture of actual objects, as well as in region segmentation of a color image other than color picture.

SUMMARY OF THE INVENTION

[0009] Accordingly, an object of the present invention is to provide a technique that can divide a color image into appropriate color regions according to colors with less errors.

[0010] According to one aspect of the present invention, a color image is divided into appropriate color regions according to colors. Plural representative colors are set, and angle indices and distance indices are calculated for each pixel color in the color image in a predetermined color space of at least two dimensions. The angle indices for a particular pixel color represent angles between an individual color vector representing the particular pixel color and plural representative color vectors of the plural representative colors. The distance indices for a particular pixel color represent distances between the particular pixel color and the plural representative colors. Composite distance indices are then calculated for each pixel color in the color image, based on the distance indices and the angle indices. Each pixel in the color image is classified into plural representative color regions associated with the plural representative colors according to the composite distance indices, thereby dividing the image region of the color image into the plural representative color regions.

[0011] Since the region dividing is executed by using both the angle indices and the distance indices, the color image can be divided into appropriate regions according to colors with less errors than the conventional techniques.

[0012] In another aspect of the present invention, the composite indices are calculated for each arbitrary individual color in the color space. The correspondence between each arbitrary individual color and the plurality of representative colors are obtained in advance to form a lookup table storing the correspondence. Pixels in the color image are classified into plural representative color regions with the aid of the lookup table.

[0013] The present invention can be implemented in various embodiments, such as a method and an apparatus for dividing a color image region, a method and an apparatus for generating a mask by using the results of the region dividing, a method and an apparatus for inspecting a circuit board, a method and an apparatus for generating a lookup table to be used for the region dividing of a color image, a computer program for implementing the functions of these various methods or apparatuses, a computer program product or a recording medium having the computer program stored thereon, and data signals embodied in a carrier wave including the computer program.

[0014] These and other objects, features, aspects, and advantages of the present invention will become more apparent from the following detailed description of the preferred embodiments with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0015] **FIG. 1** shows the configuration of a printed circuit board inspection apparatus as one embodiment of the present invention.

[0016] **FIG. 2** shows a color image of a printed circuit board PCB.